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## PROBLEM-SOLVING OR PRACTICE IN THINKING. II<sup>1</sup>

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*Synopsis of preceding article.*—The preceding article was concerned with “problems of everyday life,” and brought out the following points: 1. Such problems vary from very large questions of policy to minute issues requiring only a moment’s thought for their solution. 2. Consequently, in school we need many *small* problems as well as *larger* ones. 3. Both *practical* problem-solving and *speculative* problem-solving prevail in daily life. 4. Playful, speculative problem-solving, “just for fun,” is a very characteristic human activity and has large social value. 5. The great *variety* of problems found in daily life appears when we try to classify them as mechanical, diplomatic, moral, expressional, aesthetic, scientific, mathematical, etc. 6. Consequently, training in problem-solving may be provided in many subjects in the school. 7. In order to start problems for pupils, we must know what a problem is psychologically and how it originates. 8. For our purposes, a problem may be defined as a *question involving doubt*. 9. Problems originate in something puzzling, perplexing, confusing, disconcerting, unexpected, queer, strange, or “funny.” 10. When a pupil’s mind is challenged by something of this nature, he has a genuine problem. 11. Both “presented” problems and “discovered” problems abound in daily life. 12. Sometimes everyday problems are solved by an individual working alone, but many are solved by problem-solving group discussions. 13. Hence, practice in the solution of group problems through group discussion trains pupils in a very useful social art. With this social setting of problem-solving in mind we shall turn our attention to a number of actual lessons which will illustrate how training in problem-solving has been organized by progressive teachers.

### II. ACTUAL LESSONS ILLUSTRATING PROBLEM-SOLVING IN SCHOOL

#### A. SEVENTH GRADE: SHOULD THE UNITED STATES PRODUCE ITS OWN SUGAR?

*Illustrates results of preceding training in problem-solving.*—The first lesson which we shall describe is taken from an upper-grade class in order to illustrate what large issues may be considered reflectively by pupils who are about to graduate from an elementary

<sup>1</sup> This is the second of a series of four articles on this topic.

school in which training in problem-solving is provided from the kindergarten up. After presenting this upper-grade example, we shall describe lessons from the kindergarten and the second and fifth grades, in order to illustrate the gradual progress in the pupils' reflective abilities as they advance through the grades. All the lessons are from the Elementary School of the University of Chicago, but similar instruction may be found in hundreds of progressive schools throughout the country. The seventh-grade geography lesson which we shall present first was taught by Miss Edith Parker.<sup>1</sup>

*Relation to preceding lessons. Pupils reviewing various factors in America's progress.*—The class was reviewing the geography of the United States, following a previous study of it in the fourth grade some years before. As the University Elementary School completed its work in seven years, the culmination of the geography training was so organized at the end of the seventh grade that it gave the pupils an opportunity to use their geographic knowledge in considering certain large geographic problems of their native country.<sup>2</sup> As this class was studying the country in 1919, shortly after the close of the war, they had been especially impressed with the marvelous achievements of the United States and had become interested in the following large question as the basis of the review: "What are the factors that make the United States such a great nation?" In discussing the matter, they had brought forward a number of geographic factors such as the location and size of the country, its varied topography and natural resources, the character and amount of immigration, etc. For a few days they had concerned themselves with ascertaining the relative achievements of the United States and other countries in crop production. They had studied the cotton and corn crops, and had waxed enthusiastic

<sup>1</sup> To satisfy the curiosity of the reader, I may say that Miss Parker and the author of these articles are not related. Hence it is not inappropriate for me to remark that Miss Parker's technique in conducting problem-solving lessons is a model of artistic teaching of this type. We shall describe some of her fifth-grade geography lessons later in these articles.

<sup>2</sup> For a description of the course in geography in this grade, see the *Elementary School Journal*, XVIII (December, 1917), 271-79. For an article illustrating Miss Edith Parker's general procedure in organizing a large project problem in geography, see her paper entitled "The Partition of Africa—A Seventh-Grade Geography Unit," *Elementary School Journal*, XX (November, 1919), 188-202.

over our production of these staples. They next turned their attention to sugar production, and it was at this stage that the lesson which I shall describe occurred.

*Pupils disconcerted by small sugar production. Problem keenly felt.*—After some preliminary discussion, Miss Parker raised the chief problem for the day by pointing to a graph which she had drawn on the blackboard. The pupils examined it and found that the United States *produced* in a given year only one-fifteenth of the world's supply of sugar, but *consumed* one-fifth. After their earlier findings of the enormous production of cotton and corn in America, and their general contention that a great nation should try to be self-sufficient in its production of the necessities of life, many of the pupils were nonplused at this revelation of the sugar situation. Many of them were greatly disconcerted, perplexed, and puzzled by this unexpected shock to their enthusiastic national complacency. A psychological problem situation had been skilfully and easily created by the teacher. The current shortage of sugar served to make the problem felt even more intensely.

*Problem clearly defined. Proposition to increase production written on the board.*—The problem was then clearly presented for solution. "If we produce only one-fifteenth and use one-fifth of the world's supply of sugar, what should we do about it?" Some pupils suggested that we use less; others that we grow more. One pupil finally presented a clear proposition that we produce as much more sugar as possible in order to try to meet our domestic needs. Miss Parker deliberately wrote this on the board and then asked all the pupils to decide if they agreed with it. They all did.

*Search for solution. Geographies consulted to determine possibility of raising more.*—The question then arose, why, if this was advisable, hadn't the country done it before? In answering this question, attention became centered on the word "possible" in their proposition to produce more, and the teacher asked the pupils how they could find out whether it would be *possible* for us to raise more sugar. The pupils suggested looking up in their geographies the maps and other data showing the areas of possible sugar production and the conditions governing it. They decided to deal with *cane* sugar first.

*Pupils suggest conditions; get data from maps; decide greater production is possible.*—In reply to Miss Parker's question concerning the conditions which they would have to ascertain, the pupils replied "number of growing days," "suitable soil," and "amount of rainfall." She wrote these items on the board, as she had done with a number of other crucial points in the discussion. Following their suggestion to ascertain the number of growing days needed, she directed the pupils to turn to their geographies where they found a map of the United States with a line showing how far north cane could be grown. They then compared this map with one showing actual cane production, and decided that as far as number of growing days was concerned, much more cane could be grown. Similarly they took up suitable soil conditions and rainfall and arrived at similar conclusions.

*Teacher verifies pupils' conclusion by reference to a special treatise.*—In order to verify their conclusion, Miss Parker read from a special book on sugar a statement to the effect that there were thousands of acres in the country in which conditions were favorable for raising sugar cane that were not being used for this purpose.

*Teacher held discussion to "possibility" before considering "profit."*—As all these data were being produced and were gradually bringing out the *possibility* of easily producing more sugar in the United States, one boy kept suggesting that it might not be *profitable* to do so. Miss Parker made a memorandum of his suggestion on the board for later discussion, but suggested that they finish the investigation of the crop possibilities before they took up questions of profit, since the fundamental proposition to which they had all agreed and which was written on the board stated that more should be grown if *possible*. Some difficulty was experienced in getting the boy to give up his idea of considering *profitability* before determining *possibility*.

*Pupil's suggestion of lack of profit examined. Uncertainty about original proposition.*—However, after the *possibility* had been definitely proved, Miss Parker turned to the issue of profit. The pupils readily saw that what is possible is not necessarily profitable, and began to think that maybe their proposition to which they

had all assented at the beginning, namely, to produce enough sugar to meet our needs, might not be sound. In considering why the South had not raised more sugar cane, since it is quite possible, they suggested two important factors, namely (to use their own language), "competing crops" and "cost of labor." They stated that probably portions of the South found cotton and other crops more satisfactory than cane, and that labor in Cuba was probably cheaper than in the southern states.

*Pupil suggested tariff. Teacher left it an open question.*—Thus they concluded that the United States did not produce enough sugar to meet its own needs because it could be imported so cheaply that the farmers found it more profitable to raise other crops. The period was almost ended. Hence, in order to relate the day's problem concerning sugar to the larger issue concerning the greatness of the United States and its self-sufficiency in producing the necessities of life, Miss Parker again raised the question of what we should do about the sugar problem. One boy suggested that we place a tariff on sugar. Miss Parker asked, "Who would pay the tariff?" The pupils said, "The people of the United States." "Who are the people of the United States?" she then asked. "We are," they said. She then asked if it seemed wise to make every family in the United States pay more for its sugar by means of a tariff in order that the country might produce enough sugar to meet its own needs. Without waiting for an answer, she concluded the hour by saying, "This is a problem upon which the greatest American statesmen disagree, and to which Congress devotes long discussions."

#### PRINCIPLES ILLUSTRATED BY SEVENTH-GRADE PROBLEM-SOLVING LESSON

*Broad flexible grasp of subject-matter needed by teacher in such lessons.*—This type of geography teaching is becoming common in schools where a special departmental teacher is employed to teach the subject in the middle and upper grades. It is obvious that the teacher needs a thorough mastery of the subject-matter of geography if the discussions of the pupils are to be as flexible and broad as in the foregoing lesson. The teacher in such a case has to be familiar not only with such large issues as the question of

protecting native sugar production by means of a tariff but also with such details as the number of growing days required to mature sugar cane.

*Broad knowledge anticipates issues and prepares scientific data.*—It is important to note, however, that when a teacher is thoroughly informed concerning the problem under discussion, as Miss Parker was in this case, she can anticipate the various issues that will arise, have ready the necessary scientific treatises and references, and guide the discussion so that it follows important scientific lines instead of being sidetracked on minor or irrelevant issues. Thus Miss Parker realized in advance that the pupils would need to use the map showing sugar-cane production, and to save time had a memorandum prepared of the page on which it was to be found. She knew that the pupils would reach certain conclusions that needed verification, and she had on hand a special treatise on sugar and a certain report of the Department of Agriculture, with memoranda of the pages upon which the verifications could be based.

*Pupils suggest and evaluate data and procedures.*—Yet, with all this definite anticipation, planning, and direction by the teacher, the pupils carried the main burden of solving the problem—they made all the important suggestions and evaluated most of them. Their suggestions included not only matters of fact, such as the necessity of enough growing days and of suitable soil, but also methods of procedure, for example, suggestions that they examine certain maps in their geographies to find certain data. These suggestions of procedure went even farther and included decisions concerning how the question should be subdivided and which phase should be taken up first, etc. For example, early in the hour the question arose whether to consider the possibilities of increased production of *cane* sugar or of *beet* sugar. Miss Parker had the pupils decide which of these should be investigated first. They chose cane sugar and held to it.

*Points of technique in problem-solving lesson. Rapid view.*—Before turning to other lessons which will further illustrate the special technique to be used by a teacher in guiding problem-solving by pupils, we may note briefly some points of such technique

as is illustrated in this lesson. It is not necessary to study these carefully at this point, as most of them will be illustrated repeatedly in the later lessons and will be summarized in Section IV of the discussion. However, the cumulative effect of frequent reference to them will be helpful. Miss Parker's lesson, then, had the following general characteristics found in the artistic direction of problem-solving discussions.

1. She created an intense problem frame of mind by disconcerting the pupils with a graphic representation of the contrast between our large consumption and relatively small production of sugar.

2. She had the problem for discussion clearly formulated and wrote it on the board.

3. She kept the problem clearly before the pupils by frequent reference to it as written.

4. She encouraged suggestions from the pupils not only in matters of fact or data but also in the matters of procedure, i.e., in regard to such questions as "What shall we do next?" or "How can we find out about that?"

5. She encouraged careful evaluation and criticism by the pupils of the various suggestions.

6. She gave practice in the use of scientific treatises as the source of data and as a means of verification.

7. She encouraged the attitude of desiring verification of suggestions by reference to standard authorities.

8. She conducted the lesson at a deliberate pace, so that pupils were required to think before answering. As a special device in this connection, she occasionally said, "When you have your mind made up, you may rise," and then waited until most of the pupils had risen.

9. She kept the discussion organized along definite lines by outlining on the blackboard the various important suggestions that were made, and then holding to the order in which they had decided to pursue the discussion. In this way the main problem became analyzed into a number of subordinate problems which were disposed of in an orderly manner.

*Small subordinate problems that arise give dull pupils a chance.*—These subordinate problems included some very large ones and



some small ones. Perhaps the largest that arose was the final one, namely, "Should a tariff be placed on sugar?" This seems almost as large as the original dilemma, namely, "Should the United States produce all the sugar it needs?" Somewhat smaller were these problems: "What factors make it unprofitable to grow more cane?" and "What conditions are necessary to produce sugar cane?" Still smaller were these problems: "How shall we find out how far north sugar cane can be matured?" and "How can we find out what states produce sugar cane?" The breaking up of the large issue into these smaller ones results in the lesson providing training in the solution of both large and small problems. Some of the duller pupils, who might not be able to wrestle with the larger issues involved, might readily suggest looking up a sugar-production map and be able to read from it the data needed.

In the next lesson to be presented, namely, one from the kindergarten, we shall find such small, simple problems presented that even five-year-old children can easily solve them. By reading through the other lessons which are to follow, we can see how children are gradually trained up to the point where they carry on the high-grade type of reflective problem-solving illustrated in Miss Parker's seventh-grade lesson on sugar.

#### B. KINDERGARTEN PROBLEM: HOW TO MAKE THE FRONT OF CARDBOARD STORE

*Contrast old-fashioned dictated constructions with new problem type.*—In the kindergarten and primary grades many of the problems which pupils solve concern how to make something. In the old-fashioned kindergartens, it was customary to dictate to pupils just what steps to take in constructing each object. There was little room for reflective thinking by the pupils. In a modern progressive kindergarten, on the other hand, large opportunities are given to pupils to experiment in their constructions, and the experimentation is made of a reflective thoughtful type through class discussions which the teacher organizes. In order to bring out the contrast between the old dictated type of constructive activity and the newer experimental type, we shall present first a lesson from an old kindergarten manual published in London in 1874, and then follow with a modern problem-solving lesson in

making the front of a cardboard store. In the old manual the "fifth gift" is described as consisting of twenty-seven small cubes piled together to make one large cube. Some of the small cubes were further subdivided into triangular prisms. Each child had this material before him and, in the dictated exercises, all performed the same operations as illustrated in the following quotation in which the teacher addresses the children thus:

"Show me the top three cubes in front. Place them on the back three cubes. What has our large cube become? A flight of steps or a flower stand." Then talk with the child about these objects. "Divide the flower stand into three parts in length—what does it become?" "Three narrow flights of steps." "Place the three together again. I take the middle step away, and place the three cubes upon the top step—what have we now?" etc.

While the pupils may be gaining in motor control and in ability to follow directions in such a lesson as that quoted above, and may even be quite happy in the process, it is obvious that they are not being trained in thinking and are not acquiring much skill in solving construction problems.

*Problem lesson: How to make a suitable front for a cardboard store.*—In striking contrast with such mechanical dictated activity, we find the following description of a lesson in the kindergarten of the University of Chicago Elementary School in 1918. The problem which engaged the attention of each pupil was the making of a suitable front for a small cardboard grocery store. The teacher was Miss Olive Paine.

*Relation to course of study in community life.*—According to the course in Community Life, History, and Civics in this elementary school,<sup>1</sup> the children in the kindergarten study the family in its relation to the community. Needs of the family and the community as supplied by grocery stores furnish many problems. The pupils engaged in the lesson to be described were almost ready for the first grade.

*Previous work. Trip to a grocery store.*—The children had been taken to a grocery store some days before, where they observed the arrangement of the windows, doors, front of the store, shelves inside of the store, articles on the shelves and in the windows, etc.

<sup>1</sup> See the *Elementary School Journal*, XVII (February, 1917), 397-404.

*A store of large blocks previously constructed.*—A store of some considerable size had been constructed of large blocks and was still standing in the recitation room.

*Individual stores started.*—The day before the lesson each child had almost completed a small store made from heavy construction paper or from a cardboard box. The new lesson centered in the completion of a suitable front for each store. For this purpose each child had been given a piece of construction paper somewhat larger than the front of his store. Some children had already cut out windows and doors in these sheets.

*Problem for the day. Making suitable fronts.*—The stores and fronts were brought out. The fronts were to be criticized and remade, if necessary. In short, the problem was the making of *suitable* fronts for the stores.

#### WORKING OUT OF THE PROBLEM

1. *Criticism of previous work.*—As the teacher handed a child his store and his front, she asked him to place the front in position and see if he thought it was just as he wanted it to be. Sometimes the windows extended out beyond the outside walls of the store. Sometimes the doors and windows were higher than the store.

2. *Children suggest modifications; finding how to fit the fronts.*—One child was asked how his front could have been made to fit the store. He held the sheet of pasteboard in front of the store, and folded it around the side. Miss Paine asked what that was for. The child replied: "You could paste it tight to the store to hold the front on." One child suggested folding the sheet over. The teacher asked how. Various children made suggestions, and they finally concluded the sheet might have been held up in front of the store *before* the windows and door had been cut out. The place at which to fold might have been marked with lines drawn with a pencil. Miss Paine asked how they would have marked *straight* lines. Finally, it was brought out that the sheet might be laid on the floor and folded over in a straight line by placing the edges of the top nicely together. Some of the children who needed new sheets of paper received them.<sup>1</sup> Each child was led to hold

<sup>1</sup> An interesting dilemma arises in deciding *how much* to let children *experiment* in such construction work. On the one hand it might be said that such experimentation

the sheet up in front and mark a place with the pencil; then to lay the sheet on the floor and fold it over at one side; then to hold the sheet up again and find the other side.

3. *Deciding how to make doors and windows; crude idea by one child.*—Then the children were led to see that the doors and windows must come in between the two folds thus made at the side. Some wanted two windows and one door. This time one little girl (the least able of the class, it seemed) cut a very narrow door about twice as high as her store. She was asked why so high a door. She said she wanted it that way. The other children said it was too high. The girl then said it was for an upstairs. The teacher asked if stores and houses had a high door that was for both the lower floor and the upstairs. The child held out that *hers* was all right. Finally the teacher gave her a new sheet and pretty closely directed her work and tried to get the child to see proper proportions for windows, door, etc.<sup>1</sup>

4. *Informal but directed designing and making: what next and how.*—The children worked on the floor in a perfectly informal way. They were led to *see* what the *next* thing was and to *want* to do *that* thing. *How* it could be done was discussed and worked out very skilfully. Some of the children left the part cut out for a window uncut at one end of the window. Some wanted to use this to raise up for an awning, and some wanted it for a shelf under the window. Evidently something of this kind had been done at some

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with its erroneous results is necessary for children of kindergarten age in order to get them to feel the need for the thoughtful planning which prevails in the lesson which we are describing. On the other hand, some educators would favor more direction by the teacher in order to avoid the waste of material incurred in this lesson. In the steel industry, Carnegie would tear down and throw in the scrap heap an expensive plant which had been in use only a short time in order to make way for another which afterthought had shown to be better. How much should kindergarten children be permitted similar waste in solving construction problems? A later article on the nature of problem-solving will throw some light on the dilemma.

<sup>1</sup> Children with low-grade intellects are often unable to *plan* intelligently but can acquire skill in motor arts, e.g., Goddard indicates that a certain type of moron can learn to use machinery and care for animals and needs no supervision for routine work, but cannot plan. It is a waste of time to try to train such pupils to be skilled thinkers, but it is profitable to teach them practical motor arts by careful supervision. For Goddard's convenient table showing some of the possibilities of the feeble-minded see the author's *General Methods of Teaching in Elementary Schools*, p. 304.

other time. The observer doubted if that came out accidentally on the part of so many without having been brought out at a previous lesson. However, it was quite skilfully used by many of the children.

5. *Teacher suggests standards for comparison.*—Miss Paine kept bringing out the idea of size by comparison of the relative heights of doors, windows, shelves, men, women, etc., in the store they had seen and also in the store made of blocks.

6. *Children vary ideas of hinges.*—The number of hinges needed for the door was discussed. One child had just one hinge and seemed happy. She was sent to examine a door to find out how many hinges other doors had. Different children decided that two or three hinges would be best. One boy said four would be best. He wanted that number.

7. *Intercomparison and exchange of judgments by children.*—The children were led to judge of the quality of their own work and to supplement the judgment of others concerning their work and to supplement the judgment of the teacher.

8. *Fast children plan further work.*—Two children were much quicker and showed more ability in motor co-ordination than the rest. They completed their windows and doors and were ready to go on. They were asked what they wanted to do next. They said, "Make a shelf." They were asked what they wanted to make it out of. "Pieces of cardboard." The teacher handed one a piece and asked if that would do. "It is too little," he said. The teacher said they would make the shelves the next day, as the end of the period had arrived.

9. *Articles put away until next day.*—The children were asked to get their stores and fronts ready to put up. "How will you know them?" asked Miss Paine. "Mark letters on them," they said. Then they made their initials on the inside of the stores and the fronts. Quite naturally they gathered up their scraps and put them into the waste basket.

*Evaluation of kindergarten problem-solving lesson. Remarks by trained observer.*—The foregoing account of the observed lesson, except the paragraph headlines, was written by an experienced teacher of high-school mathematics, Miss Mildred Harris, who

had become interested in problem-solving in general. She was in the process of organizing her ideas of the technique of such teaching while attending a class for supervisors of teaching. Consequently the following comments which she made as a high-school mathematics teacher observing a kindergarten construction lesson are suggestive concerning the general matter of problem-solving.

1. *Definite aims*.—The object of the lesson was clear to both teacher and children and was kept before the minds of the children all the time. Suitable fronts for the stores were to be made. This was the *object* in the *minds of the children*. In the *mind of the teacher*, many purposes were in view. Each thing done was a preparation for the next higher-level thing. Progressive development was aimed at. This was evident in her questions, suggestions, etc.

2. *Self-criticism by pupils*.—Progress was made in the children's criticism of their own work. Each child, as he worked on his own front, was led to judge his own work from time to time as it was completed at that stage. They were led to find out how they could determine if it was just what they wanted it to be. This was one of the parts of the recitation in which the teacher showed skill above the ordinary.

3. *Co-operative suggestion and evaluation*.—The matter of co-operative work, suggestions, etc., was brought out in supplementing criticisms of each other and of the teacher. The teacher worked with the pupils and they worked together and yet each child was busy with his own store front.

4. *Encouraging pupils to make suggestions*.—Independence on the part of pupils was encouraged by such questions as "What would *you* do?" "How might *you* do *this* time?" "Could *you* do it *this* way?" "If that is not just as *you* want it, *how can you make it* as *you want it* to be?"

5. *Responsibility for planning*.—Each child was led to feel his own responsibility for the making of his front, planning, etc. He was first led to see what he wanted, and then he tried to find out how he could make what he wanted.

6. *Pupils interested*.—The children were interested in their own work. This was shown in the fact that they wanted to go on even after the end of the period.

7. *Teacher anticipated pupils' difficulties.*—A child's probable difficulty was anticipated. The teacher really kept a sharp lookout on each child's work, although she seemed to be leaving the child to do as he pleased. If she saw a child marking a place that would result in the same error he was trying to avoid, she would ask him questions and get him to try to find out if that mark was just right. Sometimes she would ask a child who was about to get into trouble to look at the work of another who was succeeding and see what he thought of that. The child, without any suggestion, often got a clue for his own work and proceeded. If not, the teacher suggested something, etc.

8. *Left a problem for next day.*—The teacher left a problem in the minds of the children to be worked out for the next day—how to make the shelves on which to put the things they wanted in their stores.

NOTE.—In the next article we shall describe sample lessons from the second and fifth grades which will illustrate the practice in thinking that the pupils are given as they progress from the simple construction problems of the primary grades up to the ability demonstrated in the seventh-grade sugar-production lesson with which the present article began.

[To be continued]